CLAIMS

What is claimed is:

1. A waveguide device comprising:

a pump source operable to generate a pulsed pump beam pulsed at a pump frequency and having a pump wavelength; and

an optical waveguide structure comprising a signal waveguide and a pump waveguide, wherein the optical waveguide structure is arranged to receive the pulsed pump beam into the pump waveguide, and wherein the signal waveguide contains a gain medium that is responsive to the pump wavelength to provide instantaneous or near instantaneous gain at a signal wavelength offset from the pump wavelength and thereby generate a signal beam that amplifies by drawing energy from the pump beam.

2. The device of claim 1, wherein the pump beam has pump pulses having a pump pulse length and the optical waveguide structure has a length that is less than the pump pulse length, so that each pump pulse induces instantaneous or near instantaneous gain in the signal waveguide along the length of the optical waveguide structure simultaneously.

3. The device of claim 2, wherein at least one of the pump source and the optical waveguide structure are configurable to set the pump frequency to match a round trip frequency of the optical waveguide structure, to provide synchronous pumping.

4. The device of claim 1, wherein the pump beam has pump pulses having a pump pulse length and the optical waveguide structure has a length that exceeds the pump pulse length, so that each pump pulse induces instantaneously or near instantaneously a traveling gain field in the signal waveguide that moves through the optical waveguide structure.

5. The device of claim 4, wherein at least one of the pump source and the optical waveguide structure are configurable to set the pump frequency to match motion of the traveling gain field in the signal waveguide, to provide synchronous pumping.

6. The device of claim 1, wherein the optical waveguide structure includes an optical fiber.

7. The device of claim 6, wherein the optical fiber comprises: a core that forms the signal waveguide; an inner clad that forms the pump waveguide; and an outer clad.

8. The device of claim 1, wherein the instantaneous or near instantaneous gain is generated by stimulated Raman scattering.

9. The device of claim 8, wherein the signal waveguide of the optical waveguide structure is substantially free of rare earth elements.

10. The device of claim 1, wherein the instantaneous or near instantaneous gain is generated by stimulated emission from an energy band populated by the pump beam.

11. The device of claim 10, wherein the signal waveguide of the optical waveguide structure is doped with a rare earth element to provide said energy band.

12. The device of claim 1, wherein the pump source is a Q-switched laser.

13. The device of claim 1, wherein the pump source is an optical fiber laser.

14. The device of claim 1, wherein the pump source is a Q-switched optical fiber laser.

15. The device of claim 1, wherein the pump waveguide has a cross-sectional area relative to that of the signal waveguide that is sufficiently small to suppress higher order inelastic scattering, e.g. a ratio of 4-8.

16. The device of claim 1, wherein the pump waveguide includes an absorber material that is relatively low loss for the pump beam and relatively high loss for the signal beam.

17. The device of claim 1, further comprising a seed source for providing a seed beam at the signal wavelength, wherein the optical waveguide structure is arranged to receive the seed beam from the seed source into the signal waveguide.

18. The device of claim 1, wherein the optical waveguide structure is configured so that at least a portion of the signal beam is fed back to provide a seed beam at the signal wavelength.

19. The device of claim 18, further comprising at least one reflector arranged to feed back at least a portion of the signal beam for seeding.

20. The device of claim 18, wherein the optical waveguide structure is arranged in a ring to feed back at least a portion of the signal beam for seeding.

21. The device of claim 1, wherein the signal wavelength is offset from the pump wavelength by an amount characteristic of a single inelastic scattering event.

22. The device of claim 1, wherein the signal wavelength is offset from the pump wavelength by an amount characteristic of first and second inelastic scattering events.

23. The device of claim 1, wherein the first and second inelastic scattering events have a common characteristic energy.

24. The device of claim 1, wherein the first and second inelastic scattering events have different characteristic energies.

25. The device of claim 1, wherein the signal wavelength is offset from the pump wavelength by an amount characteristic of at least first and second inelastic scattering events.

26. The device of claim 25, wherein the length of the gain medium is selected to have a length suitable for generating a desired higher order Stokes component.

27. The device of claim 1, wherein the optical waveguide structure is predominantly made of silica.

28. The device of claim 1, further comprising a cavity arranged around the optical waveguide structure to form a laser.

29. The device of claim 1, wherein the instantaneous or near instantaneous gain is generated by inelastic scattering.

30. The device of claim 1, wherein the length of the gain medium is sufficiently small to suppress higher order inelastic scattering

31. The device of claim 1, wherein the pump beam is multimode.

32. A method of generating a signal beam, comprising:

providing an optical waveguide structure comprising a signal waveguide and a pump waveguide;

generating a pulsed pump beam having a pump energy;

introducing the pulsed pump beam into the pump waveguide; and

generating a signal beam by instantaneous or near instantaneous gain in the signal waveguide at a signal energy offset from the pump energy.

33. The method of claim 32, wherein the instantaneous or near instantaneous gain is produced by stimulated Raman scattering.

34. The method of claim 32, wherein the instantaneous or near instantaneous gain is produced by stimulated emission.